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Research Notes : Poland : Performance of some important characters of hybrid soybean (F1) in a cool climate

Grzegorz Konieczny
Academy of Agriculture

ACADEMY OF AGRICULTURE
Department of Genetics and Plant Breeding
Wojska Polskiego St. 71 C
60-625 Poznań, POLAND

Poland

1) Interdependences between some traits in early hybrid generations (F_2-F_4) of soybean.

The existence of an interdependence between some important traits of soybean is of great significance for its breeding.

In rather cool climate (Poland) interdependences between developmental traits and yield structure elements affect the possibility of fast creation and introduction of new, well-adapted and efficient cultivars into agricultural practice.

Estimation of phenotypic correlations of 11 traits was the subject of this paper.

Materials and methods: Field experiments were carried out in 1979-81. Plants of six cross combinations in early (F_2-F_4) respective generations were examined. Particular correlation coefficients were computed on the basis of the number of plants from 122 to 3770, according to combination and generation. Phenotypic correlation coefficients were computed for all combinations of pairs of the 11 traits mentioned below.

1. Period from sowing to beginning of flowering,
2. Flowering period,
3. Pod-filling period,
4. Vegetation period,
5. Plant height,
6. Number of branches per plant.
7. Number of pods per plant,
8. Number of seeds per plant,
9. Number of seeds per pod,
10. Weight of seeds per plant,
11. 100-seed weight.

This allowed us to evaluate 55 correlations of various pairs of these traits in examined populations. Correlation coefficients were computed individually for separate cross combinations and respective generations.

Results and comments: Among 55 estimated correlations between pairs of separate traits, only in 20 cases were coefficients meaningfully constant and essential in most of the investigated cross combinations and respective

generations. Only these 20 cases are taken into consideration in this article (Table 1).

The correlation between the period from sowing to flowering and the flowering period was not close but in most cases rather negative. Also, the flowering time was negatively correlated with the pod-filling period, and in this case correlation coefficients were slightly greater than in the former interdependence. These two correlations indicate that selection for short flowering time can result in extending the period from sowing to flowering and/or pod-filling period.

The period from sowing to flowering was positively correlated with plant height. This indicates that selection for higher plants can bring about a delay of beginning of flowering.

The pod-filling period was highly correlated with vegetation period and 100-seed weight. The vegetation period was positively correlated with plant height and weight of 100 seeds. These four correlations indicate that selection for earliness, height of plant, and large seeds in our conditions can be very difficult and requires searching for ways to break these unfavorable interdependences.

Morphological traits such as plant height and number of branches per plant were positively correlated with the number of pods and seeds per plant, as well as with seeds per pod and individual seed yield. These correlations show that selection for higher and more bushy plant types can be effective in yield potential. Among yield structure elements, rather high and positive interdependences were observed. Negative, consistent, but inconsiderable, correlation was observed only between the number of seeds per pod and weight of 100 seeds. Positive, rather close and consistent relationships between most of yield structure elements allows the breeders to reduce the number of traits taken into consideration, when they intend to select soybean for yield potential alone.

Discussion: Other researchers have dealt with interdependences between yield and other traits in soybean. Many investigators searched for traits that would be highly correlated with seed potential. Discovery of such trait (or traits) can improve selection for yield, which shows a rather small heritability coefficient in comparison with other characters. To find traits that would constitute good indicators of yield potential still is a very difficult task. Johnson and Bernard (1963) found that, in north latitude conditions, the great difficulty in soybean selection was presented by negative correlation

Table 1. Phenotypic correlation coefficients

Trait	Generation	Cross combination: PI 238920 x Oyachi No. 2	PI 238920 x PI 180509	PI 238920 x PI 180517	PI 248405 x Nordia-1	PI 248405 x PI 194643	Fiskeby V x PI 180502
		Period from sowing to flowering					
Flowering period	2	-0.40**	0.27**	-0.13**	-0.04	-0.01	0.17**
	3	-0.51**	-0.08	-0.02	-0.25**	-0.36**	-0.03
	4	-0.02	-0.03	-0.18	-0.03	-0.04	
Plant height	2	0.27**	0.24**	0.05	0.32**	0.59**	0.30**
	3	0.11	0.12	0.17**	0.29**	0.31**	0.44**
	4	0.45**	0.12	0.01	0.36**	0.06	
		Flowering period					
Pod-filling period	2	-0.15	-0.32**	-0.33**	-0.59**	-0.62**	-0.62**
	3	-0.15	-0.28**	-0.27**	-0.81**	-0.52**	-0.64**
	4	-0.27**	-0.48**	-0.21*	-0.43**	-0.39**	
		Pod-filling period					
Vegetation period	2	0.90**	0.82**	0.77**	0.47**	0.42**	0.70**
	3	0.57**	0.90**	0.89**	0.24**	0.60**	0.41**
	4	0.65**	0.61**	0.80**	0.62**	0.56**	
100-seed weight	2	0.47**	0.28**	0.26**	0.36**	0.29**	0.19**
	3	0.18	0.50**	0.36**	0.08	0.36**	0.15**
	4	0.10	0.24**	0.47**	0.41**	0.10	
		Vegetation period					
Plant height	2	0.36**	0.33**	0.19**	0.53**	0.59**	0.49**
	3	0.43**	0.52**	0.59**	0.43**	0.16**	0.60**
	4	0.49**	0.49**	0.64**	0.65**	0.58**	
100-seed weight	2	0.51**	0.38**	0.36**	0.47**	0.34**	-0.04
	3	0.32**	0.55**	0.39**	0.13	0.41**	-0.09
	4	0.03	0.23**	0.52**	0.26**	0.09	

Table 1. Continued

Trait	Generation	Cross combination: PI 238920 x Oyachi No. 2	PI 238920 x PI 280509	PI 238920 x PI 180517	PI 248405 x Nordia-1	PI 248405 x PI 194643	Fiskeby V x PI 180502
	Plant height						
Pod number per plant	2	0.17*	0.38**	0.41**	0.18*	0.33**	0.53**
	3	0.27**	0.24**	0.14**	0.07	0.39**	0.22**
	4	0.14	0.07	0.42**	0.13	0.29*	
Seed number per plant	2	0.12	0.31**	0.38**	0.15	0.31**	0.57**
	3	0.29**	0.29**	0.22**	0.03	0.43**	0.25**
	4	0.07	0.06	0.31**	0.24	0.32*	
Seed weight per plant	2	0.19*	03.5**	0.42**	0.21*	0.32**	0.53**
	3	0.34**	0.39**	0.33**	0.18*	0.40**	0.14**
	4	0.06	0.13	0.44**	0.24	0.20	
	Number of branches per plant						
Pod number per plant	2	0.50**	0.58**	0.61**	0.59**	0.62**	0.63**
	3	0.42**	0.34**	0.46**	0.37**	0.49**	0.26**
	4	0.67**	0.54**	0.43**	0.37**	0.39**	
Seed number per plant	2	0.51**	0.53**	0.57**	0.57**	0.61**	0.66**
	3	0.39**	0.33**	0.46**	0.40**	0.53**	0.13**
	4	0.28**	0.42**	0.39**	0.17**	0.38**	
Seed weight per plant	2	0.52**	0.53**	0.53**	0.58**	0.57**	0.61**
	3	0.36**	0.29**	0.43**	0.32**	0.39**	0.23**
	4	0.30**	0.48**	0.31**	0.27**	0.15	

Table 1. Continued

Trait	Generation	Cross combination: PI 238920 x Oyachi No. 2	PI 238920 x PI 280509	PI 238920 x PI 180517	PI 248405 x Nordia-1	PI 248405 x PI 194643	Fiskeby V x PI 180502
	Pod number per plant						
Seed number per plant	2	0.95**	0.96**	0.97**	0.98**	0.97**	0.95**
	3	0.95**	0.93**	0.93**	0.91**	0.95**	0.84**
	4	0.65**	0.86**	0.91**	0.77**	0.80**	
Seed weight per plant	2	0.92**	0.95**	0.95**	0.95**	0.95**	0.92**
	3	0.93**	0.85**	0.88**	0.80**	0.92**	0.80**
	4	0.64**	0.74**	0.85**	0.73**	0.62**	
	Seed number per plant						
Seed number per pod	2	0.57**	0.36**	0.44**	0.19*	0.23**	0.52**
	3	0.49**	0.56**	0.44**	0.30**	0.42**	0.53**
	4	0.57**	0.35**	0.33**	0.33**	0.50**	
Seed weight per plant	2	0.94**	0.96**	0.97**	0.97**	0.96**	0.96**
	3	0.95**	0.91**	0.93**	0.87**	0.93**	0.90**
	4	0.84**	0.78**	0.88**	0.81**	0.77**	
	Seed number per pod						
Seed weight per plant	2	0.44**	0.29**	0.37**	0.13	0.13	0.48**
	3	0.36**	0.48**	0.40**	0.26**	0.30**	0.42**
	4	0.57**	0.14	0.27**	0.15	0.36**	
100-seed weight	2	-0.24**	-0.21**	-0.12	-0.35**	-0.12	-0.21**
	3	-0.03	-0.22**	-0.04	-0.11	-0.25**	-0.26**
	4	-0.15	-0.39**	-0.10	-0.20	-0.03	
	Seed weight per plant						
100-seed weight	2	0.33**	0.31**	0.35**	0.39**	0.28**	0.03
	3	0.38**	0.53**	0.30**	0.28**	0.20**	0.20**
	4	0.06	0.37**	0.50**	0.45**	0.56**	

*Significant level 0.05. **Significant level 0.01.

between early maturity and plant height as well as by a positive correlation of plant height and seed yield. Our investigations corroborated these interdependences in all analyzed cross combinations and generations. Skorupska and Konieczny (1985) found in an experiment with two cross combinations (F_4) correlation values for earliness and plant height equal -0.45 and -0.20, for earliness and seed weight per plant -0.64 and 0.09, and for the same two crosses in F_3 and F_4 generations for plant height and seed yield per plant in F_3 -0.34; 0.22, and in F_4 0.30 and -0.23, respectively, for cross "A" and "B". According to Fedorowska (1981), the value of correlation coefficient between plant height and vegetation period was 0.21. The present investigations produced significantly greater value of this coefficient (Table 1). In our conditions, direct interdependence between the vegetation period and seed yield per plant was small, insignificant, and variable. Such creation of the latter interdependence in hybrid plants (F_2 - F_4) allows us to state that selection for early forms with satisfactory yield potential in spite of great difficulties can bring expected results.

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Grzegorz Konieczny

2) Performance of some important characters of hybrid soybean (F_1) in a cool climate.

Obtaining intervarietal hybrids of *Glycine max* (L.) Merrill in a cool climate such as in Poland (latitude above 50°N) is one of the most important problems for development and introduction of original cultivars of this species.

In 1977, hybrid soybean seeds were obtained for the first time in our Academy through field crossing of various forms (cultivars and PI's). Characteristics of some important traits of F_1 plants in comparison with their parental forms were the subject of this paper.

Materials and methods: This study presents characteristics of F_1 individuals and their parental forms in Wielkopolska region (latitude 51-53°N).

Cross components and their characteristics for a three-year period in Polish conditions are presented in Table 1.

Table 1. Characteristic of parental forms from three-year observations (1975-77)

Cultivar or PI	Vegetation period (days)	Plant height (cm)	Seed weight per plant (g)	Seed number plant	100-seed weight (g)
Fiskeby V	124	29.0	6.5	34.0	19.5
Nordia-1	136	58.7	10.4	58.0	18.6
Oyachi No. 2	164	61.0	6.3	24.0	21.4
Merit	176	78.0	8.9	61.0	14.6
PI 180499	166	82.0	15.0	80.0	18.7
PI 180502	160	84.0	11.7	68.0	18.0
PI 180509	142	63.0	12.7	69.0	17.4
PI 180517	143	68.0	11.2	62.0	17.7
PI 194643	130	52.0	8.1	40.0	18.7
PI 238920	135	58.0	7.2	39.0	18.9
PI 248405	150	60.0	8.0	42.0	19.6
PI 297503	169	64.0	14.0	78.0	18.7

Seeds of the F_1 generation were planted on April 27, 1978, in the field of Experimental Station at Swadzim. Distances between rows were 0.5 m, and interplant space in rows was 0.4 m. Parental forms were planted in the same

Table 2. Characteristic of F_1 plants in comparison with their parental forms in 1978

Combination	Number of plants	Number of days from sowing to flowering	Number of days of flowering	Number of days of pod filling	Number of days of vegetation	Plant height (cm)
Oyachi No. 2 x PI 238920	2	74	26	73	173	59.5
PI 238920 x Oyachi No. 2	1	71	29	84	184	65.0
PI 238920 x Merit	1	92	26	64	186	120.0
PI 238920 x PI 180499	2	78	52	56	186	97.0
PI 238920 x PI 180509	4	84	47	42	173	59.0
PI 238920 x PI 180517	3	82	20	69	171	53.7
PI 238920 x PI 297503	1	77	54	55	186	95.0
PI 248405 x Nordia-1	2	69	30	71	170	73.0
PI 297503 x PI 238920	2	83	35	68	186	86.6
PI 248405 x PI 194643	5	68	39	66	173	86.2
Fiskeby V x PI 180502	3	57	35	51	143	82.7
Fiskeby V	10	46	13	54	113	42.6
Nordia-1	10	64	40	66	170	60.2
Oyachi No. 2	10	74	26	73	173	64.0
Merit	10	84	34	67	185	75.8
PI 180499	10	66	52	67	185	78.3
PI 180509	10	85	33	67	185	63.1
PI 180507	10	85	19	66	170	45.8
PI 194643	10	61	39	70	170	66.0
PI 180502	10	60	69	39	168	86.2
PI 238920	10	73	27	73	173	58.0
PI 248405	10	66	30	77	173	50.1
PI 297503	10	66	44	75	185	66.5

Number of				Weight of	
branches per plant	pods per plant	seeds per plant	seeds per pod	seeds per plant (g)	100 seeds (g)
7.0	61.5	88.0	1.4	19.0	21.6
7.0	31.0	40.0	1.3	9.5	23.6
10.0	30.0	31.0	1.0	3.0	9.7
8.0	22.5	32.0	1.4	4.0	12.5
5.8	55.0	68.2	1.2	12.9	18.7
6.7	75.7	98.3	1.3	18.5	18.8
9.0	12.0	4.0	0.3	0.5	12.5
6.0	74.5	102.0	1.4	17.3	16.9
6.8	13.2	8.5	0.6	1.1	12.8
5.2	35.6	57.8	1.6	11.5	19.9
10.3	117.7	221.0	1.9	42.1	19.0
5.0	67.4	130.4	1.9	22.6	17.3
3.2	26.9	34.4	1.3	4.6	13.2
4.5	17.3	24.2	1.4	6.7	27.7
4.3	26.3	35.5	1.4	3.0	8.5
3.0	13.7	21.0	1.5	2.8	13.2
5.3	21.3	28.3	1.3	4.2	15.1
5.0	32.7	51.3	1.6	6.8	13.3
5.5	21.2	30.1	1.4	3.9	12.9
8.2	50.2	93.2	1.8	23.5	25.2
4.1	17.5	20.9	1.2	3.5	16.8
3.1	21.9	31.3	1.4	4.1	13.0
5.2	18.5	21.3	1.2	1.8	8.6

Table 3. Relative value of morphological and yield structure traits of F_1 plants in comparison with their maternal (P_1) and paternal (P_2) forms, in percent

Combination	Plant height		Number of Branches per plant		Number of Pods per plant	
	P_1	P_2	P_1	P_2	P_1	P_2
Oyachi No 2 x PI 238920	93.0	102.6	155.5*	155.5*	355.5	351.4*
PI 238920 x Oyachi No. 2	112.0	101.6	155.5*	155.5*	177.1*	179.2
PI 238920 x Merit	206.9	158.3*	222.2*	232.5	171.4	114.1*
PI 238920 x PI 180499	167.2	123.9*	177.8*	266.7	128.6*	164.2
PI 238920 x PI 180509	101.7	93.5	128.9	109.4*	314.3	258.2*
PI 238920 x PI 180517	92.6	117.2	148.9	134.0*	432.6	231.5*
PI 238920 x PI 297503	163.8	142.8*	200.0	173.1*	68.6	64.9
PI 297503 x PI 238920	130.2*	149.3	130.8*	151.1	73.1	75.4
PI 248405 x Nordia-1	145.7	121.3*	193.5	187.5*	340.2	276.9*
PI 248405 x PI 194643	172.0	130.6*	167.7	94.5	162.5*	168.7
Fiskeby V x PI 180502	194.1	95.9	206.0	125.6*	174.6*	234.4

*Relative trait value in which heterosis vigor was noted in comparison with more efficient parental form.

Number of				Weight of			
Seeds per plant		Seeds per pod		Seeds per plant		100 seed	
P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
363.6*	421.0	100.0	116.7	283.6*	542.8	78.0	128.7
191.4	165.3*	108.3	93.0	271.4	141.8*	141.6	85.8
148.3	87.3	83.3	71.4	85.7	100.0	57.6	114.4
153.1	152.4*	116.7	93.3	114.3*	142.8	74.5	94.9
326.3	243.6	100.0	92.3	368.6	307.1*	111.3*	124.0
470.3	191.6*	108.3	81.2	528.6	272.0*	112.2*	141.3
19.1	18.8	25.0	25.0	14.3	27.8	74.5	145.5
39.9	40.7	50.0	50.0	61.1	31.4	148.9	99.4
325.9	296.5*	100.0	107.7	421.9	376.1*	130.1	127.9
184.7*	193.0	114.3*	114.3*	280.5*	294.9	152.8*	154.4
169.5*	237.1	100.0	105.5	186.3	179.1*	109.8	75.4

pattern next to F_1 plants. Some phenological traits (flowering and maturity), morphological traits (plant height, number of branches per plant), and yield structure elements (number of pods and seeds per plant, number of seeds per pod, weight of a hundred seeds) were observed.

Results: *Phenological characters.* F_1 plants and their parental forms emerged between the 12th and 14th of May. The emergence of the above forms was not observed earlier than that. In analyzed populations of F_1 plants, the earliest blooming was observed in plants of the cross Fiskeby V x PI 180502 - 57 days after planting (Table 2). Parental forms of this cross started to flower after 46 and 60 days from sowing, respectively. The shortest period of flowering (only 20 days) was observed in cross PI 238920 x PI 180517, in which parental forms flowered for 27 and 19 days, respectively. The period of pod filling varied. The shortest one was observed in F_1 plants from PI 238920 x PI 180509 combination in which it was 42 days only. Pod-filling period for parental forms was 73 and 67 days, respectively. Plants from particular cross combinations were characterized by different vegetation periods. The shortest one was observed in F_1 plants of Fiskeby V x PI 180502 -- only 143 days -- and was intermediate in comparison with their parental forms, which vegetated 113 and 168 days, respectively. Phenological traits are important qualities, especially in long day conditions. Breeders are looking for plants that start to flower early and flower not too long, are rather thermoneutral and photoperiodneutral and also usually mature early.

Morphological characters. Plants in 6 of 11 observed cross combinations were taller than both their parents (Tables 2 and 3). In cross PI 238920 x PI 180517, F_1 plants were intermediate in comparison with their parental forms. In 10 combinations, F_1 plants produced more branches than their parental forms (Tables 2 and 3).

Yield structure elements. Observations of the number of pods and seeds per plant and weight of seeds per plant indicated that most F_1 plants were distinctively more productive than their efficient parental forms. Plants in the analyzed population, regarding the number of seeds per pod, were not so much differentiated as regarding the characters mentioned above. Weight of 100 seeds was differentiated according to the particular crosses. F_1 plants from crosses PI 248405 x PI 194643, PI 248405 x Nordia-1, PI 238920 x PI 180509, and PI 238920 x PI 180517 produced larger seeds than parental forms with heavier seeds (Tables 2 and 3).

Discussion: Jaranowski et al. (1980) reported that foreign soybean genotypes obtained in similar latitude as in Poland (the same daylength) significantly prolonged their vegetative period in our conditions. Similar reaction was observed in Sweden by Holmberg (1973). For this reason, soybean breeders in Poland create a new original genetic variation by means of crossing different genotypes coming from various regions, especially of high north latitude. Some reports provide information about F_1 plant traits as compared with their parental forms. Kalton (1948), Leffel and Weiss (1958), Brim and Cockerham (1961), Chaudhary and Singh (1974), Paschal and Wilcox (1975), and Kunta et al. (1985) described the heterosis effect of several characters in F_1 plants. They found significant hybrid vigor but none of them reported F_1 plants characterized by so much better traits as compared with the more efficient parent in the experiment. For instance, in cross PI 248405 x Nordia-1, F_1 plants yielded 276.1% more (grams of seeds per plant) than their better parent. In the same cross, it was found that the number of seeds per plant exceeded the better parental form above 196.5%. Such distinct hybrid vigor in F_1 plants was probably due to poor environmental conditions for soybean growing in Poland.

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